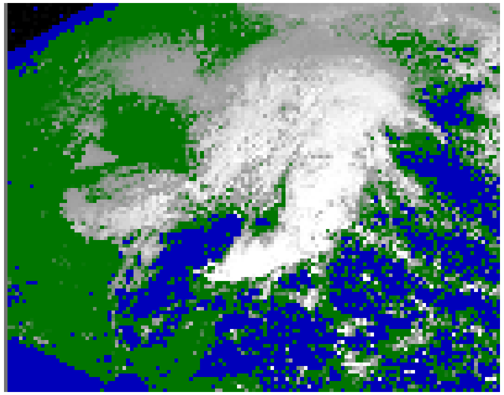


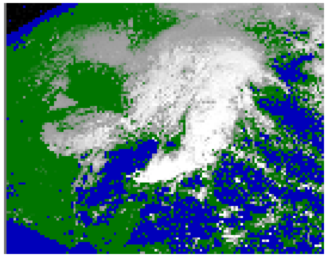
GEWEX CLOUD SYSTEM STUDY
WORKING GROUP 3
EXTRA-TROPICAL LAYER CLOUDS

•Mandate: Improve representation of extratropical layer clouds in global models

•Uniqueness: Mandate includes improvement of boundary layer, cirrus, convective, and some polar clouds

•Problem: Not quite certain what is really wrong with extratropical layer clouds in global models

•Approach: Simulation of real world storm cases with a suite of atmospheric models



GEWEX CLOUD SYSTEM STUDY
WORKING GROUP 3
EXTRA-TROPICAL LAYER CLOUDS

Key Scientific questions identified by Working Group 3

- How important is it for climate and weather models to correctly parameterize sub-grid scale mesoscale cloud structure and cloud layering in extra-tropical cloud systems?

- Why are the components of the water budget associated with mid-latitude cloud systems poorly represented in climate models?

- What level of complexity of microphysical processes needs to be parameterized in order that weather and climate models can correctly simulate extra-tropical cloud systems?

- Is there an optimal combination of GCM resolution and sub-grid scale parameterization?

- What processes are not properly parameterized, and are there specific threshold scales for critical features?

WG3 Publications

Ryan, BF, 1996: On the global variation of precipitating layer clouds. *Bulletin of the American Meteorological Society*, **77**, 53-70.

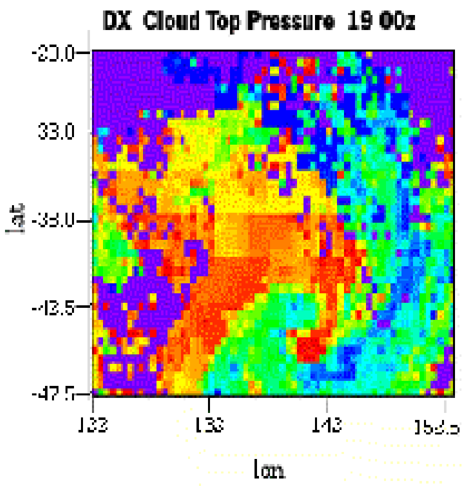
Stewart, R.E., K.K. Szeto, R.F. Reinking, S.A. Clough and S.P. Ballard, 1998: Midlatitude cyclonic cloud systems and their features affecting large scales and climate. *Reviews of Geophysics*, **36**, 245-273.

Szeto, K. K., and U. Lohmann, 1999: Cloud-resolving and single column simulations of a warm-frontal cloud system: Implications for the parameterization of layered clouds in GCMs, *Geophysical Research Letters*, **26**, 3113-3116.

Katzfey, J.J. and B.F. Ryan, 2000: Mid-latitude clouds: GCM scale modelling implications. *Journal of Climate*, **13**, 2729-2745.

Ryan, B.F., J.J Katzfey D.J Abbs, C. Jakob, U. Lohmann, B. Rockel, L.D. Rotstayn, R.E. Stewart, K.K. Szeto G. Tselioudis and M. K. Yau, 2000: Simulations of a cold front by cloud-resolving, limited-area and large-scale models and model evaluation using in-situ and satellite observations. *Monthly Weather Review*, **128**, 3218-3235.

Tselioudis G., and C. Jakob, 2002: Evaluation of midlatitude cloud properties in a weather and a climate model: dependence on dynamic regime and spatial resolution. *Journal of Geophysical Research*, submitted.



CASE 1: Australian Cold Front (CFRP)

•CRM, LAM, SCM, and AGCM simulations were evaluated using satellite and field study observations

•Results are presented in Ryan et al. 2000

Some important findings:

•Models produced realistic cloud structures in the strongly-forced mature stage of the storm but did not do as well in the weakly-forced beginning stage

•Models failed to reproduce the prefrontal mid-level cloud layer and overpredicted the prefrontal cirrus cloud amounts

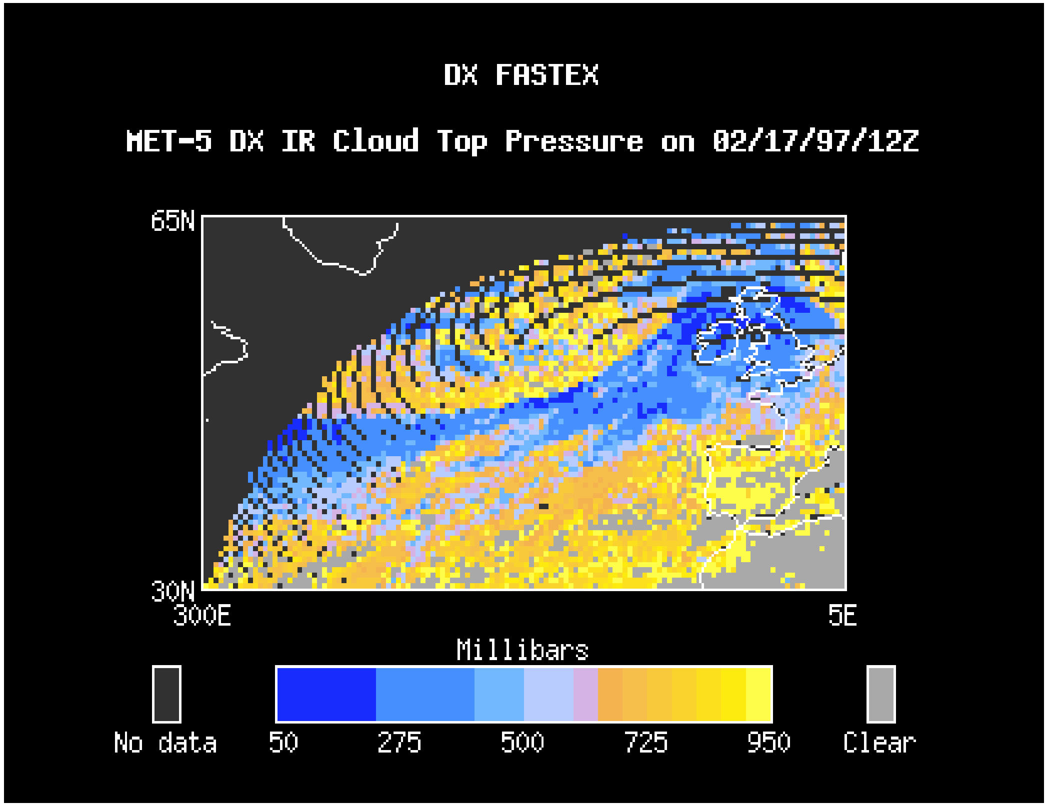
•The suppression of the prefrontal midlevel cloud may be due to too strong sublimation of ice crystals falling from the cirrus layer

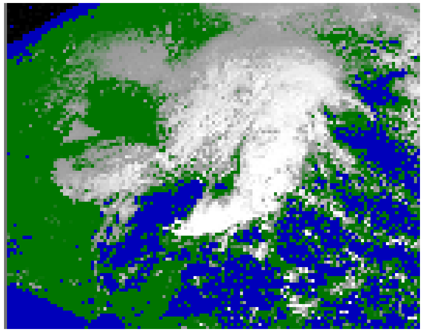
•Climate model resolution runs failed to simulate the frontal cloud structures

CASE 2: North Atlantic Storm (FASTEX)

•CRM, and LAM simulations are been evaluated using satellite and field study observations

•Paper is in preparation

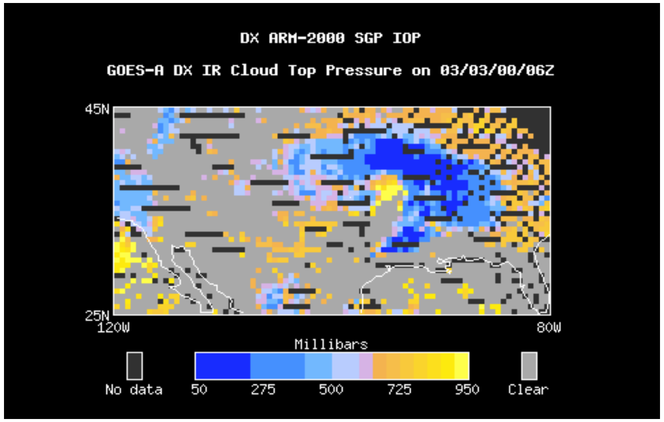




GEWEX CLOUD SYSTEM STUDY
WORKING GROUP 3
EXTRA-TROPICAL LAYER CLOUDS

FUTURE CASES

ARM March 2000 IOP

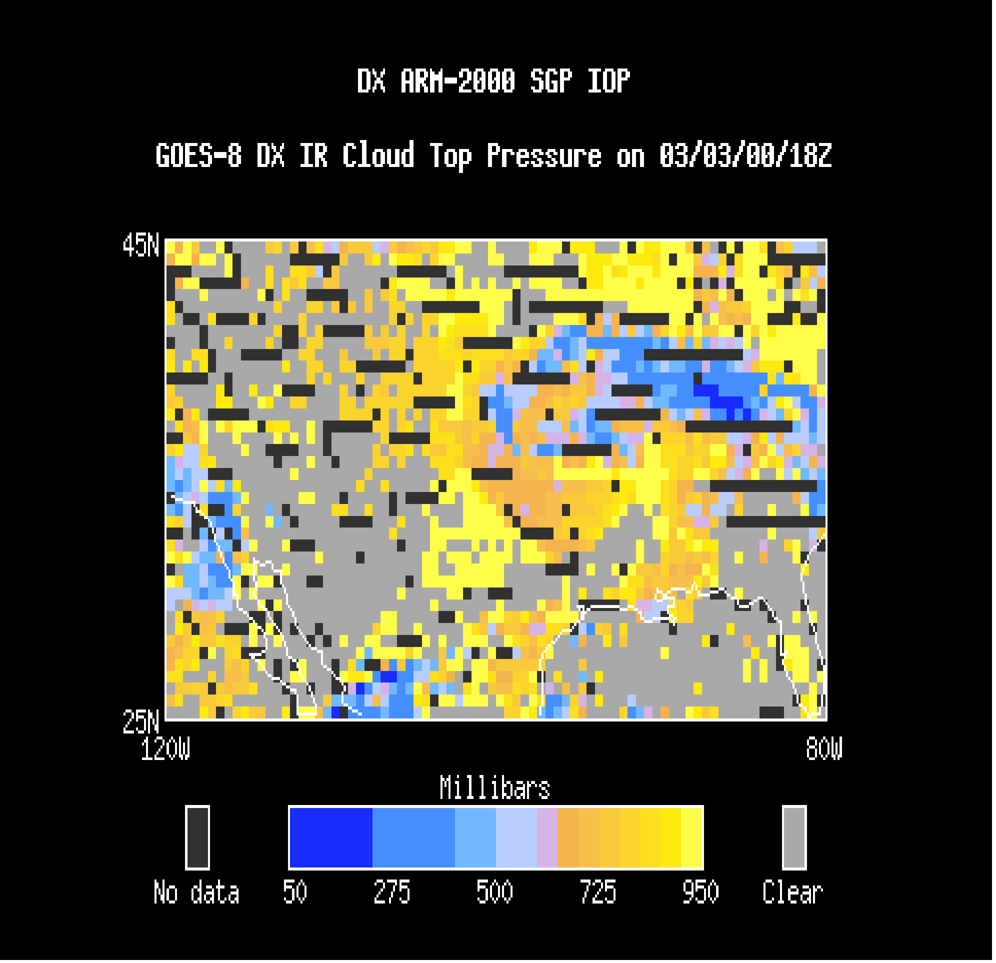


•DIME-based model initialization and evaluation process

•Evaluation of storm cloud structures from storm-event model simulations and of cloud property statistics from month-long model runs

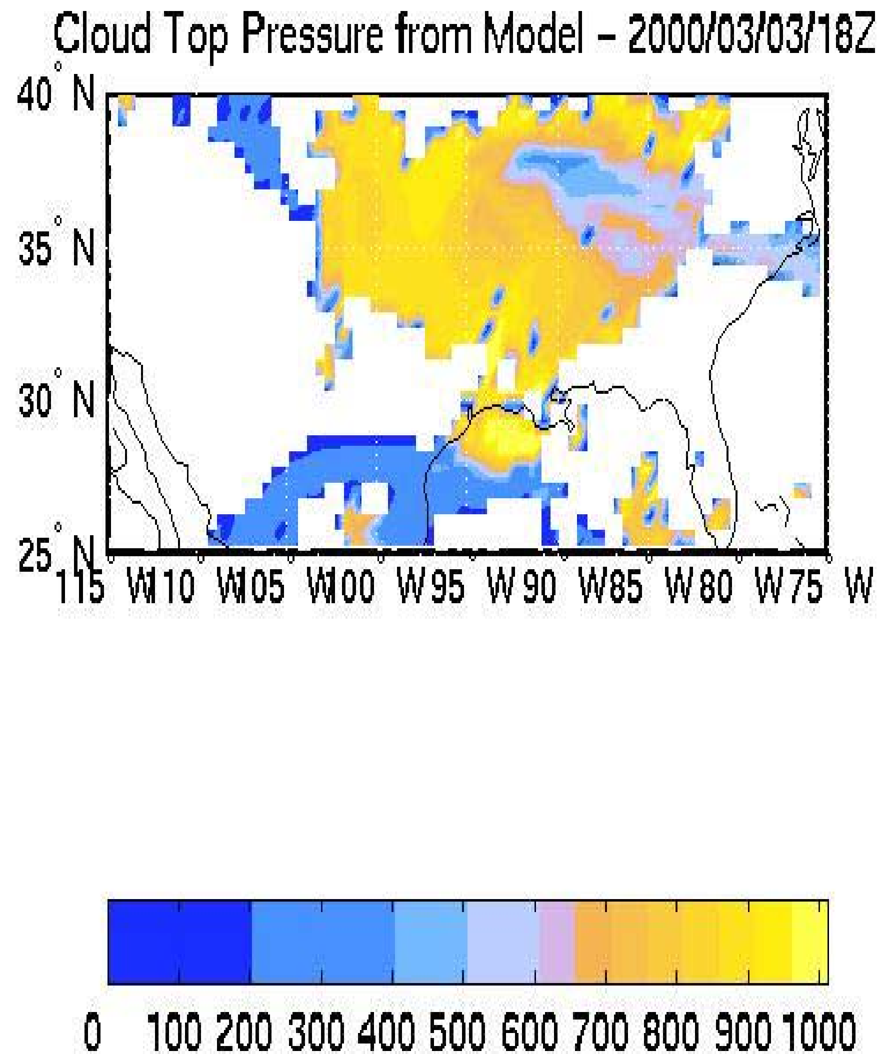
Japan Sea Experiment:

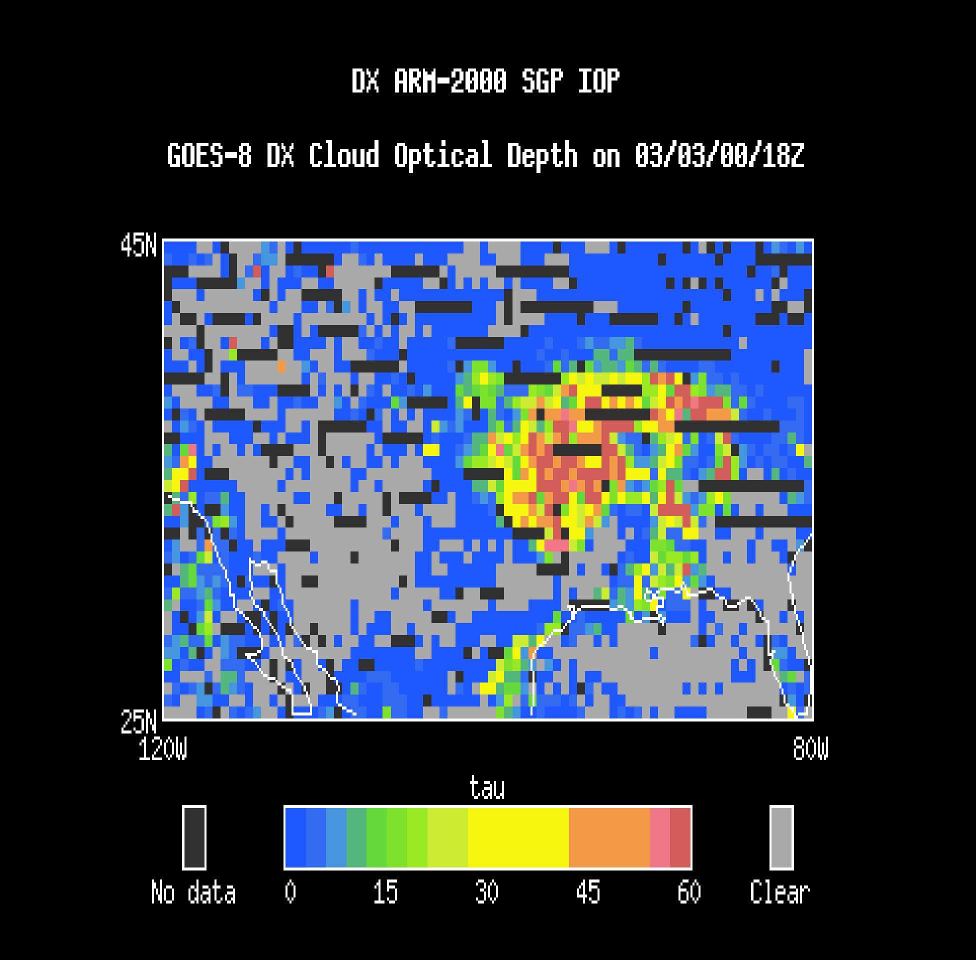
Upcoming presentation by Dr. Nakamura



ISCCP DX

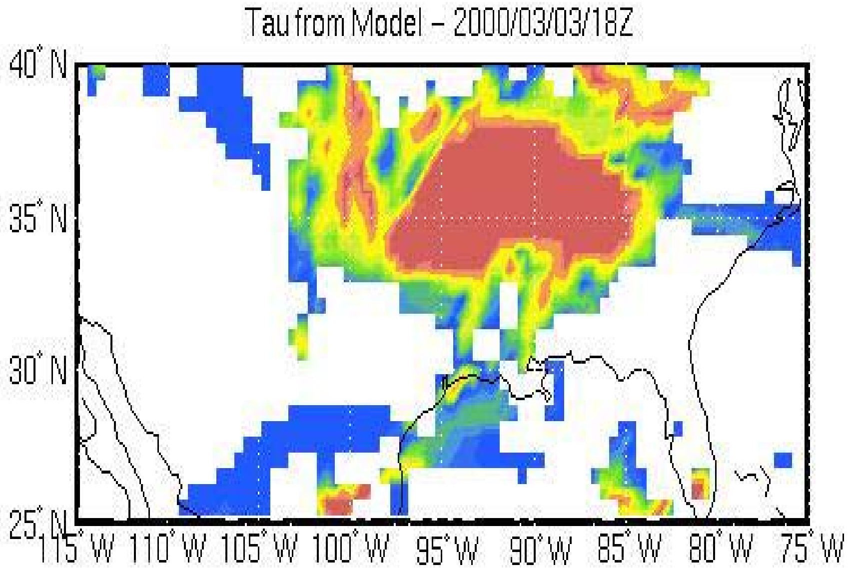
DARLAM Model

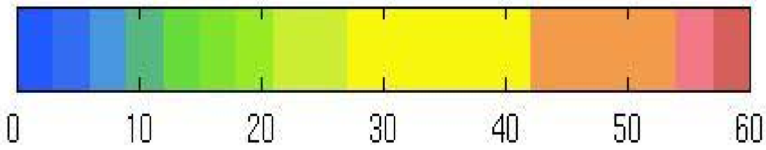




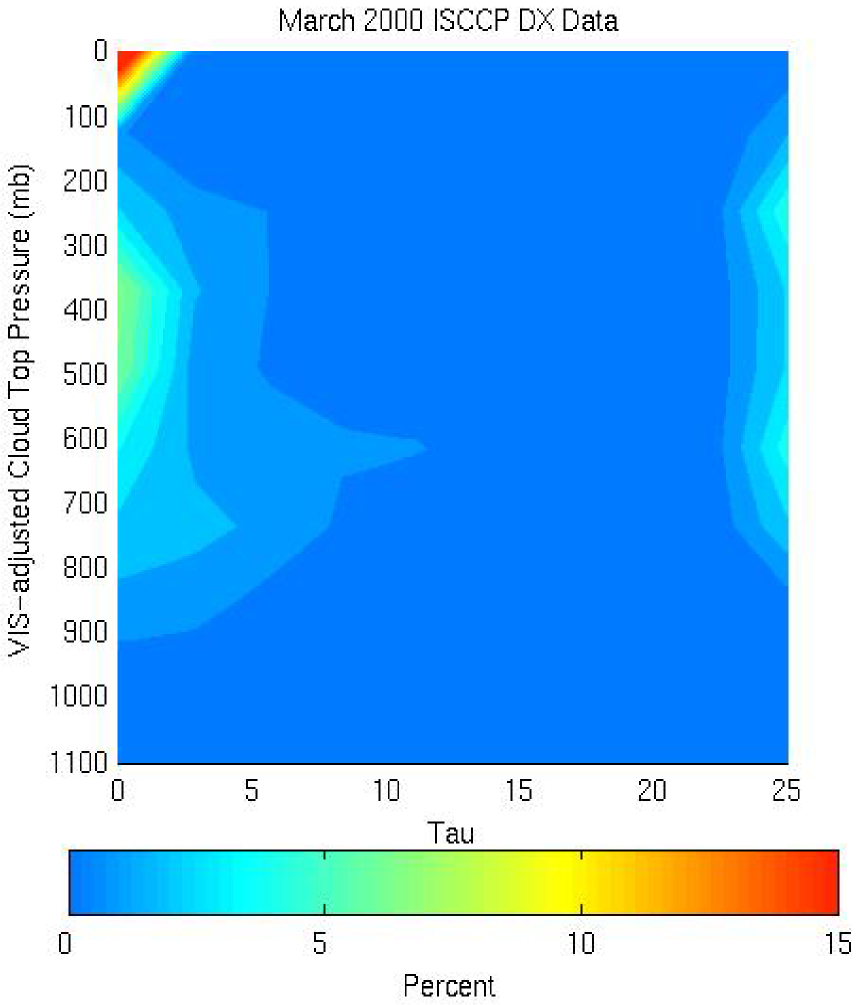
ISCCP DX

DARLAM Model



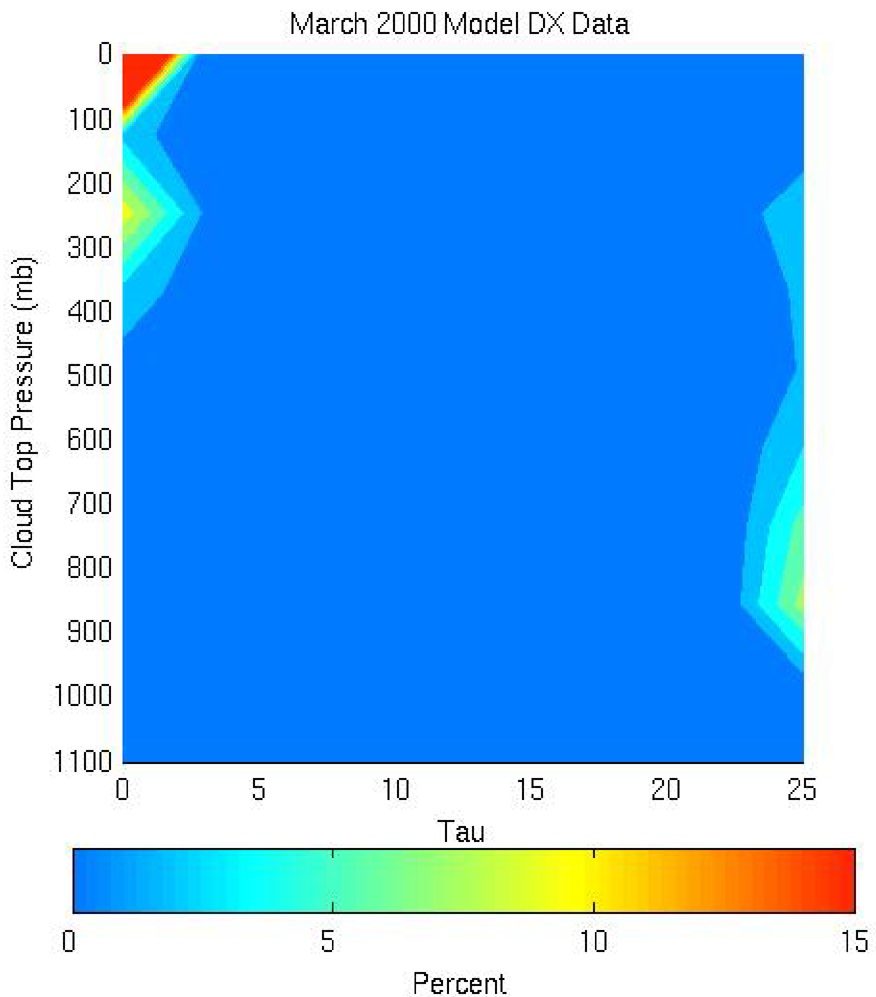


CENTRAL US STATISTICS

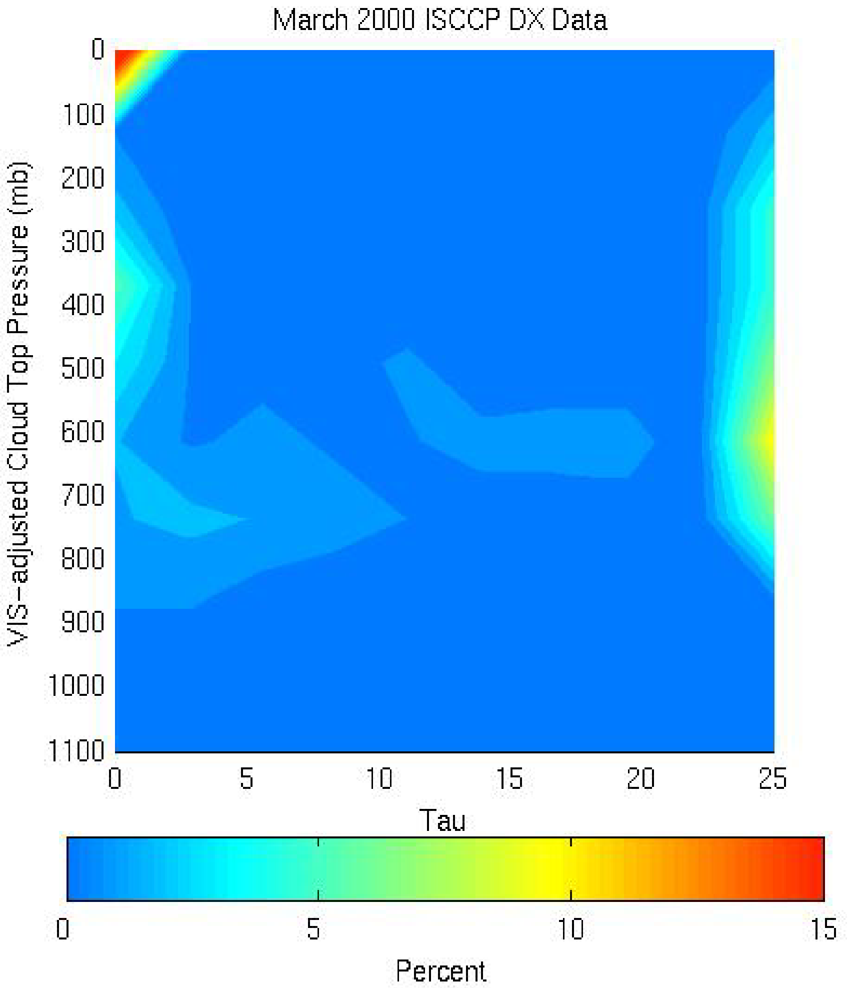


ISCCP DX

DARLAM Model

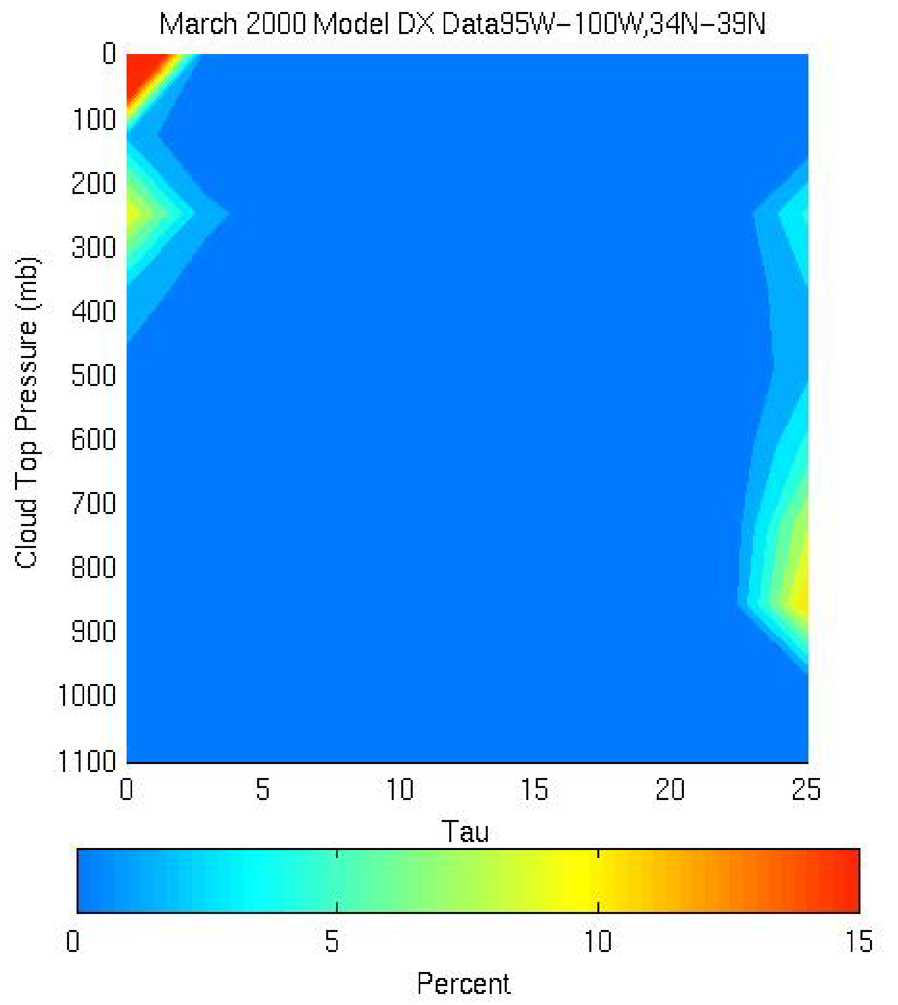


SGP SITE STATISTICS



ISCCP DX

DARLAM Model



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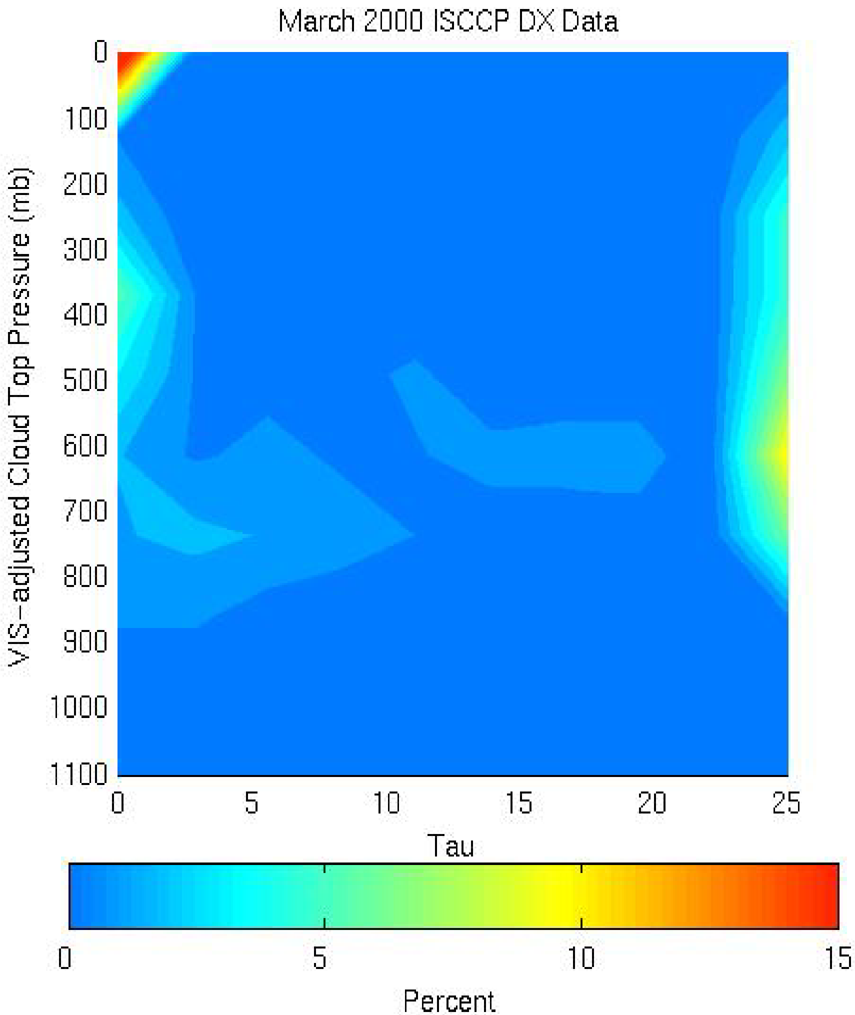
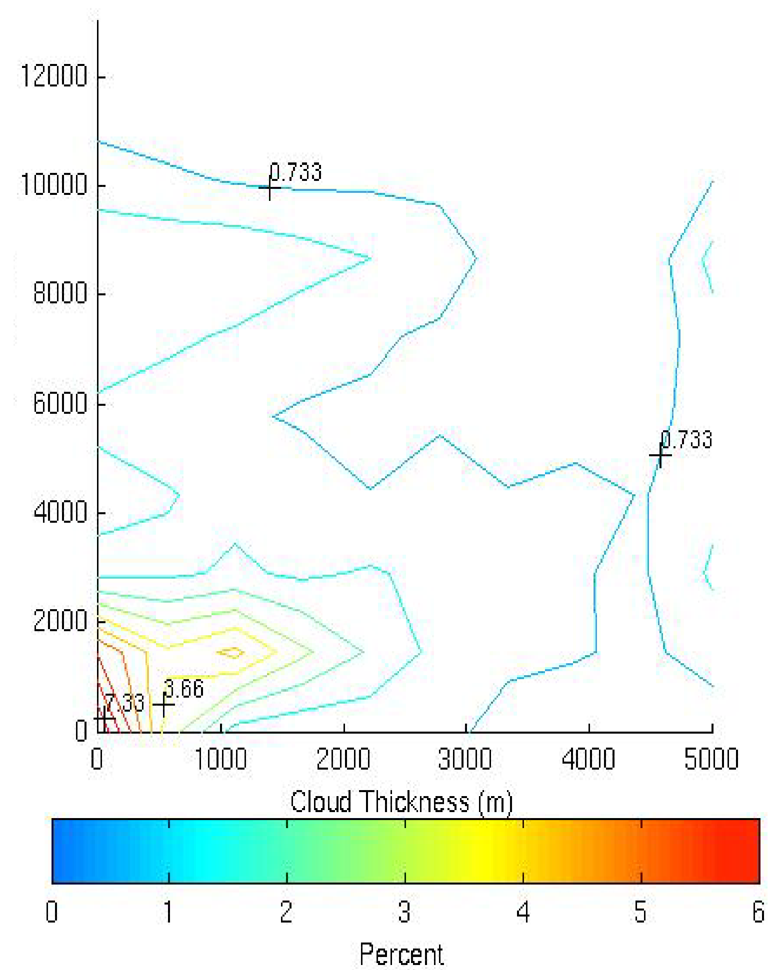


ISCCP DX

ARM SGP MMCR



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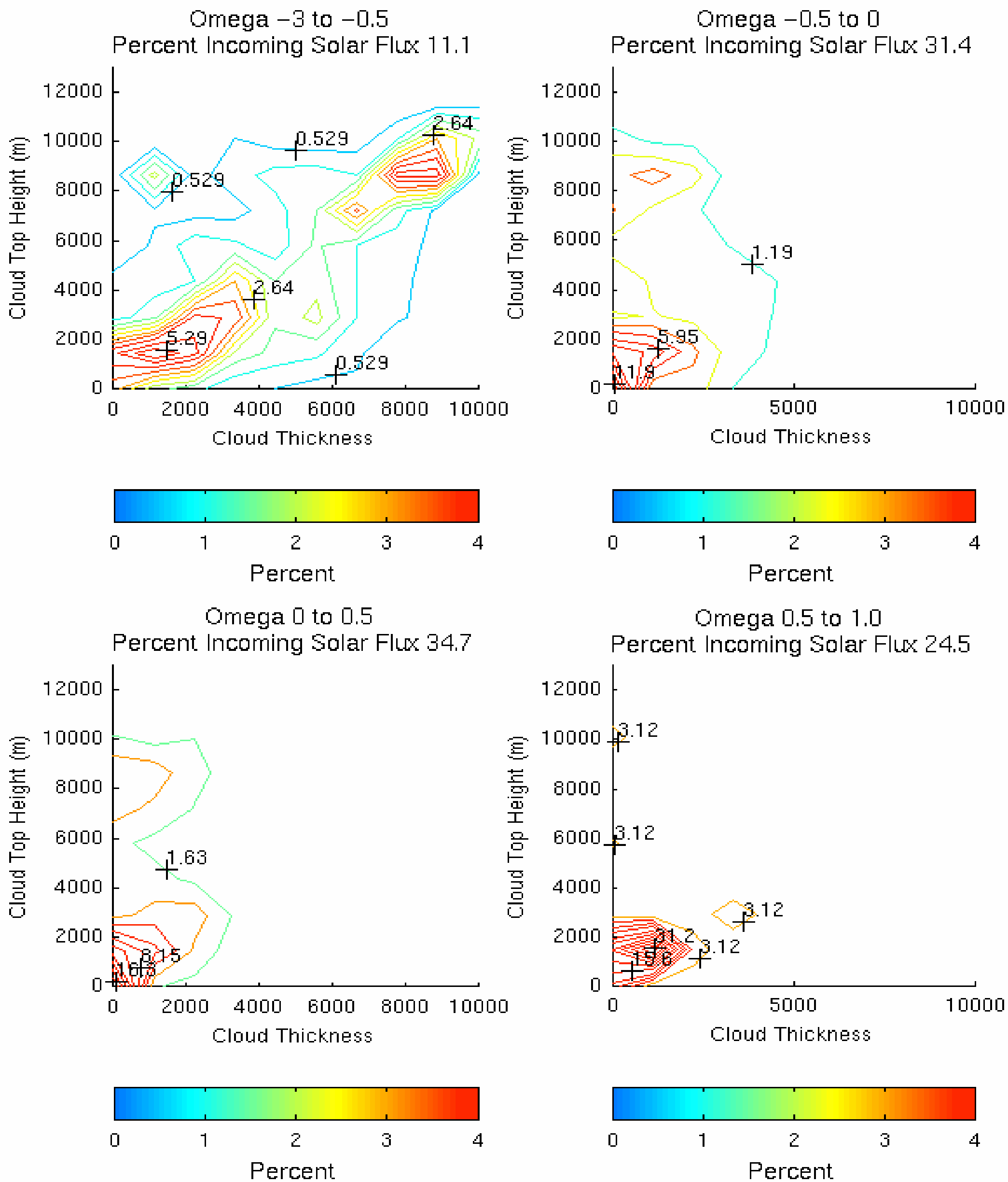
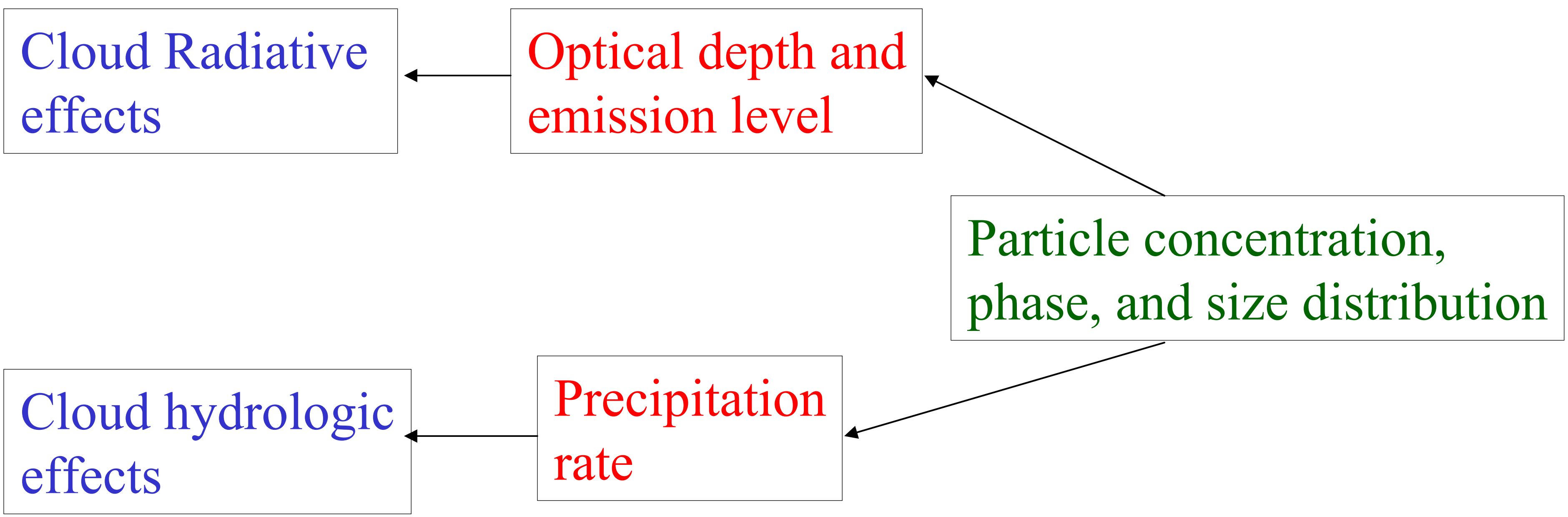
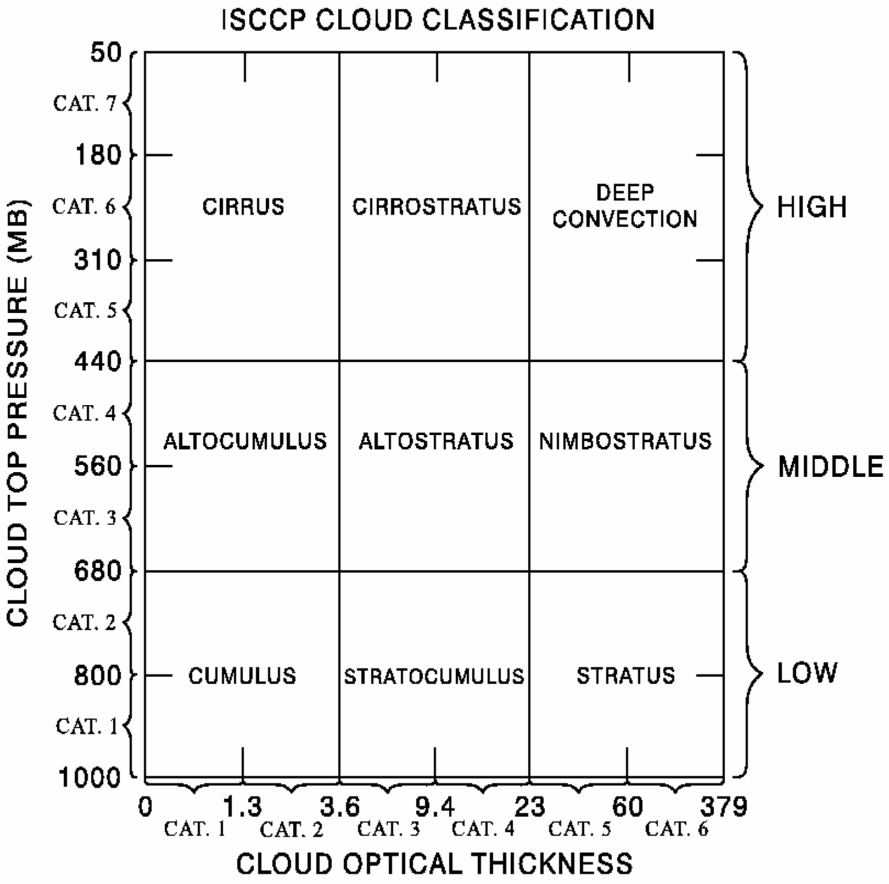


What is wrong with global model midlatitude layered clouds?

What do we need to simulate correctly?



An evaluation of climate and weather model cloud radiative properties



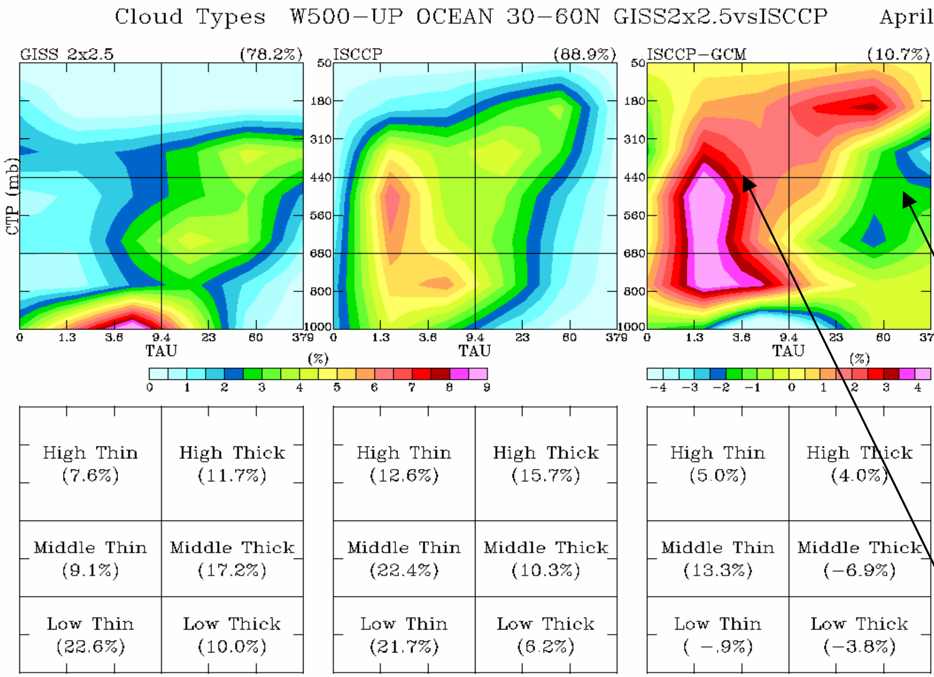
* GISS climate and ECMWF weather model were evaluated

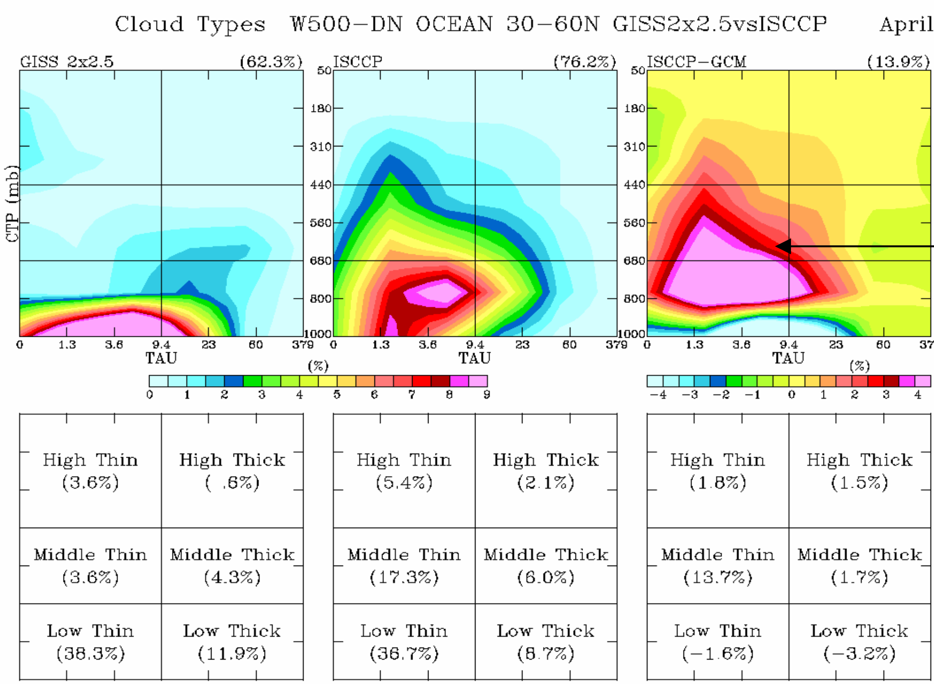
* Monthly distributions of optical depth and top pressure were compared to ISCCP retrievals

* Analysis was done separately for upward and downwards 500mb vertical velocity and for land and ocean locations

GISS GCM 2x2.5x32

APRIL OCEAN 30-60N



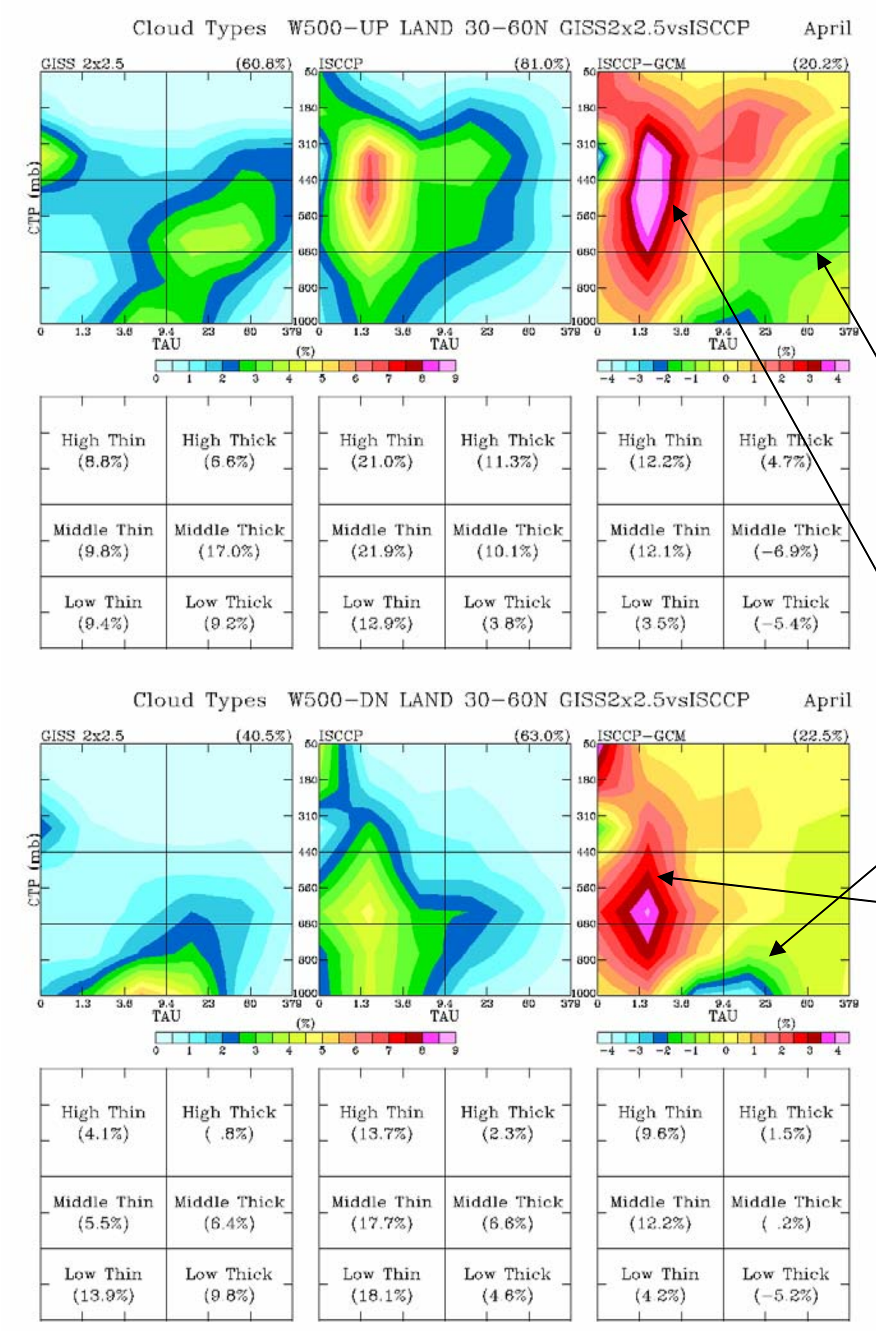


* GCM is missing ~ 11% and 14% cloud cover in the two regimes

* GCM clouds are too optically thick primarily in the W-UP regime

* GCM is missing high and middle thin clouds in the two regimes

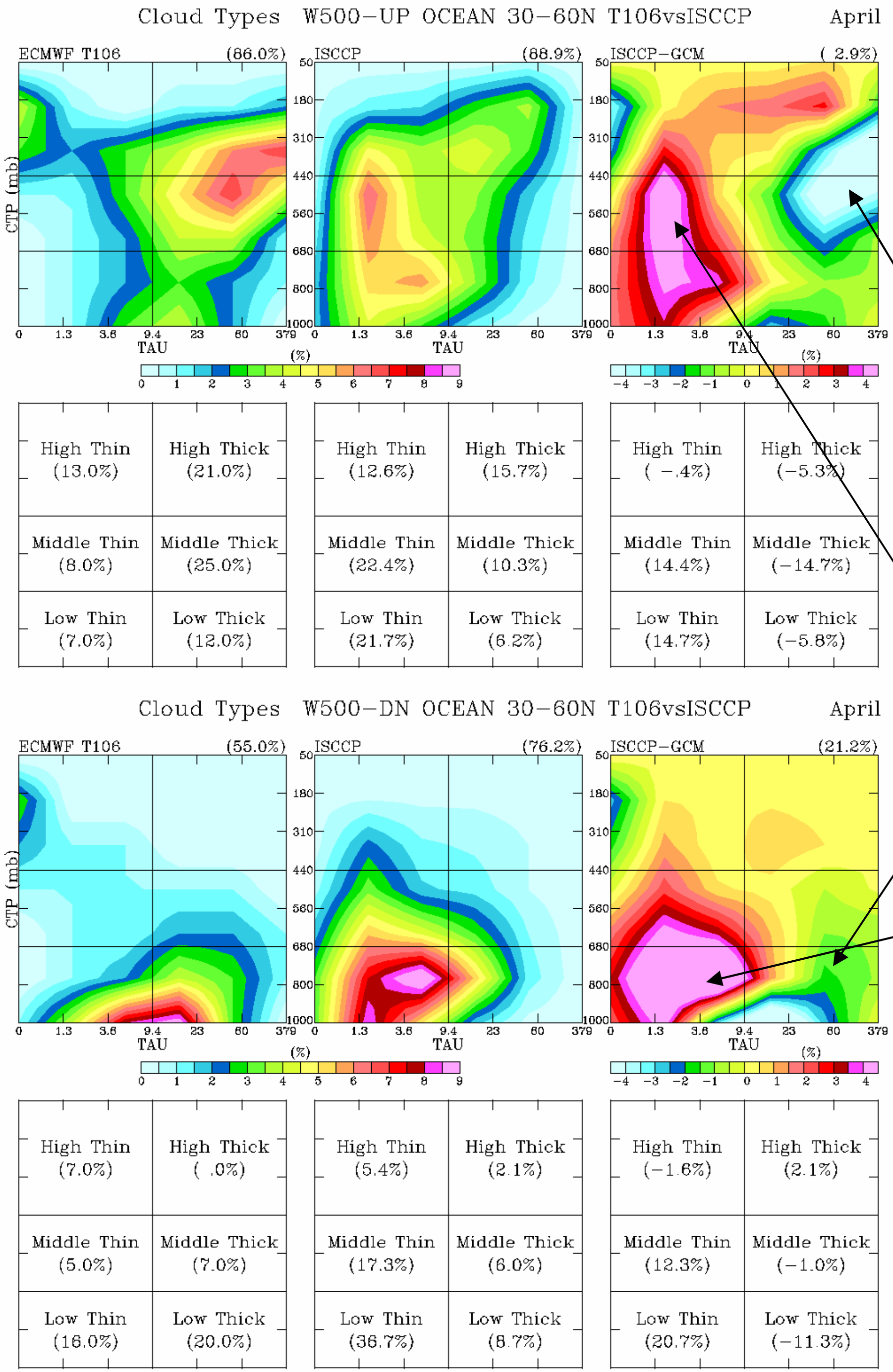
GISS GCM 2x2.5x32
APRIL LAND 30-60N



* GCM is missing ~ 20% and 22% cloud cover in the two regimes

* GCM clouds in all regimes are too optically thick

* GCM has too few high and midlevel thin clouds



ECMWF GCM T106

APRIL OCEAN 30-60N

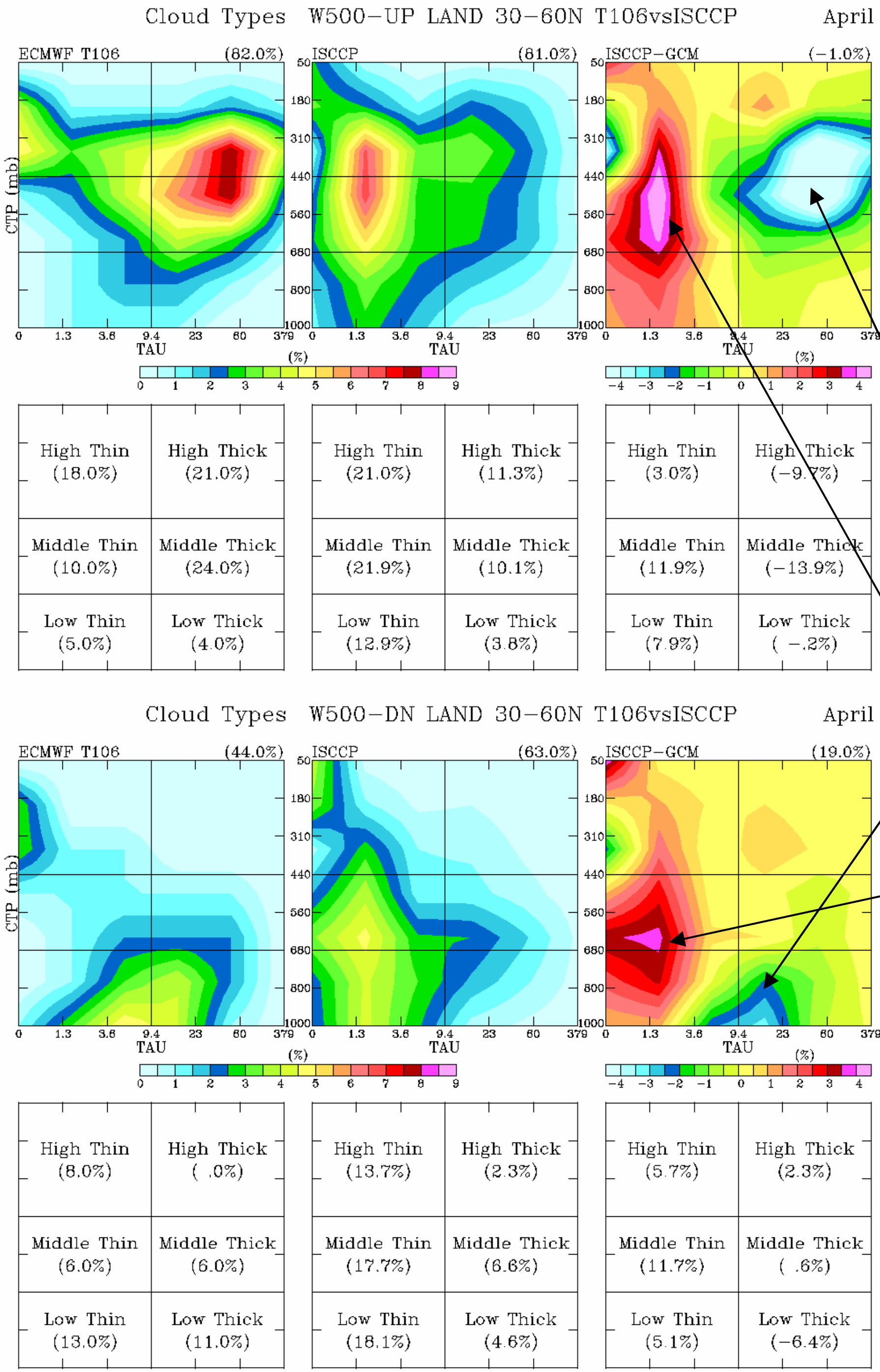
* GCM is missing ~ 3% and 21% cloud cover in the two regimes

* GCM clouds are too optically thick in all regimes

* GCM is missing middle and low level thin clouds in both regimes

ECMWF GCM T106

APRIL LAND 30-60N



* GCM is missing 19% cloud cover in the W-DN regime

* GCM clouds are too optically thick in all regimes

* GCM is missing middle and low thin cloud in all regimes

APRIL

	ISCCP - GCM	GISS 4x5x9	GISS 2x2.5x32	ECMWF T42	ECMWF T106
W-UP OCEAN	ΔCLC (%)	19.7	10.7	-3.1	2.9
	R	0.06	0.3	0.14	0.12
	$\Delta\alpha_{cl}$ ($\Delta\alpha_{sc}$) (%)	-15 (-2.1)	-7.5 (-1.4)	-18.3 (-18.2)	-17 (-13.4)
	ΔCTP (mb)	-118	-80.7	44.3	31.3
W-UP LAND	ΔCLC (%)	28	20.2	-3	-1
	R	0.2	0.16	0.37	0.31
	$\Delta\alpha_{cl}$ ($\Delta\alpha_{sc}$) (%)	-16.8 (1.62)	-13.3 (-0.5)	-9.2 (-8.9)	-16.4 (-13.8)
	ΔCTP (mb)	-92.6	-87.9	-26	31.3
W-DN OCEAN	ΔCLC (%)	35.8	13.9	21.2	21.2
	R	0.22	0.48	0.5	0.38
	$\Delta\alpha_{cl}$ ($\Delta\alpha_{sc}$) (%)	-15 (6.5)	-2.1 (3.6)	-10.7 (1.5)	-12.3 (0.7)
	ΔCTP (mb)	-152	-117	-37	-33
W-DN LAND	ΔCLC (%)	35.5	22.5	13	19
	R	0.16	0.34	0.55	0.41
	$\Delta\alpha_{cl}$ ($\Delta\alpha_{sc}$) (%)	-19.3 (5.8)	-12.2 (2.1)	-1.6 (3.2)	-10.3 (1.4)
	ΔCTP (mb)	-136.4	-126.2	-147	-90.2

* All models underestimate cloud cover in the W-DN regime
* All models overestimate cloud albedo in both regime
* Cloud height is underestimated in all regimes by the GISS GCM and in the W-DN regime by the ECMWF GCM

* Resolution increase from 4x5x9 to 2x2.5x32 improves cloud properties dramatically in the GISS GCM, but resolution increase from T42 to T106 shows no appreciable change in the ECMWF GCM

What should be fixed in global model midlatitude layered clouds?

• Cloud optical depths are too large in both upward- and downward-moving air regimes. Cloud water content is overestimated in the water budget calculations or cloud vertical extents are too large.

• Cloud covers are too small in downward-moving air regimes. Boundary layer may be too dry or subsidence too strong.

• Cloud top heights are too low in downward-moving air regimes. Turbulent mixing or shallow convection may be too weak.

• Increases in resolution from 4 to 2 degrees show great improvements in midlatitude cloud property simulations but further increases to about 1degree show little change